

Smart Traffic Signals

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Abstract: *The concept of traffic signals that work in the absence of man power on the road is what is essential for efficient traffic movement. This concept of the RF transmitter receiver is aimed to control traffic in a simple and effective way thereby reducing traffic wait times. People in other countries have been testing out various methods of achieving this same goal. Their tries have been partly successful BUT is practically very difficult to achieve and is expensive to implement. The ideas already existing heavily rely on IOT and such concepts become very difficult to implement in a city whose population exceeds the population of some countries combined. These ideas are very expensive to implement as they deal with installation of certain modules within the vehicles which in turn communicate with the traffic signals via the internet.*

Keywords: Poisson Distributions, Signals, RF Transceiver, Mean, Variance, Level

1. Introduction

Traffic problems are common in today's world where travelling is a task people perform irrespective of the time of the day. In this era of smart devices, where everything is connected and everything is designed to be more efficient than its previous version, there are certain aspects of living that are not smart as of the present day. One such device is a traffic signal. Every traffic signal consists of a control module, where an operator manually changes the order of traffic lights and also the time that each signal remains a particular color at a particular side of the road.

In the absence of such an operator or a traffic policeman, a timer is set for each traffic signal. These timers do help in indicating the wait times but they are not dynamic in function. These signals do not account for the number of vehicles on that particular side of the road and also do not change the wait times based on the time of the day. A road is usually pack jammed during peak hours and also during the evenings and moderate during other times of the day. These peak hours are what lead to people waiting for a long time on the roads.

84 lakh people reside in the city of Bangalore and over 60 lakh vehicles have been registered. The time spent by citizens commuting everyday averages to about 34.8 minutes a day. The average speed of travel during peak traffic hours is 19kmph.

This absence of good traffic signal systems leads to decrease in productivity of the people living in the overcrowded cities and these reasons sparked the idea of smart traffic systems.

The idea though very interesting; is extremely challenging. In our country where traffic rules are usually broken and lane discipline is not heeded to, assessing the number of vehicles in a unit area of the road in unit time becomes very tedious. Hence to develop such a system, certain assumptions have been made to simplify calculations.

2. Abbreviations & Acronyms

The different parameters that determine the performance of the signal were recorded.

The parameters were:

- λ : Average arrival rate per unit time.
- t : Duration of each counting interval.
- y : The uniform level at which the probability of vehicles approaching it is calculated.
- n : the duration of the signal when green for a given side.
- μ : Mean of the levels.
- T : Total time for one cycle of the signal.
- k : Number of cars for each level.

3. Case Study

For the development of the smart traffic system using rf transmitter receivers, certain mathematical expressions have been utilized. Each road is different from the other in terms of the number of vehicles that are present on that road, dimensions, quality and location of the road. All these factors influence the traffic and hence a single road has been considered for analysis.

The vehicles are considered to be cars as stated in the assumptions and this is done due to 2 reasons. The first reason being the incompatibility of the bikes to operate effectively with the transmitter receiver and the second being that bikers tend to maneuver to the front of the signal with ease and without the waiting time cars undergo at the same signal.

Initially the road is divided into various levels. Each level consists of 3 lanes which are assumed to be occupied by 4 vehicles. Each of these levels are then found to contain an average of 16 vehicles. Hence the number of levels taken into consideration depends on the vehicular density on that particular road. When traffic builds up, a random vehicle is selected in level 1.

After the selection of the vehicle, the time taken for that vehicle to cross the traffic signal is taken. Similarly, 4 more trials are taken for the same level for other vehicles waiting at the signal. Total waiting time is calculated for each trial and the average waiting time is estimated. This procedure of calculating waiting time is repeated for other levels. In this case, it is repeated up to level 5.

Poisson's distribution is then utilized to calculate the probability of a vehicle being present at that level. Based on these probability values, the sum is obtained and is observed to be equal to unity. The signal times are then calculated for each side of the road based on these probabilities.

Each signal consists of a certain number of pairs of transmitter receivers. When a vehicle blocks the signal transmitted and does so for a specified duration of time, the traffic time is calibrated based on the level up to which such intrusions are detected. This time calibrated for one side of the road influences the wait times on the other sides of the road. This process is then repeated on the other sides.

3.1 Tables

Table 1: Counting interval for selective levels

y	t (seconds)
2	45
3	65
6	118
4	64
5	64

3.2 Equations

The RF transmitter is placed on one side and the receiver is placed across the road in line of sight of the transmitter.

The maximum time up to which the receiver doesn't receive the signal is 5 seconds. This enables us to detect the status of the level.

When 'n' levels are filled, the nth level is considered as I for further computation.

We assume that the arrival rate of vehicles from all directions to an intersection are random and obey Poisson's distribution.

$$P(y) = \sum_{m=0}^k \frac{(\lambda t)^{my} e^{-(\lambda t)}}{(my)!} \quad (1)$$

Mean of the levels for a road is given by:

$$\mu = \frac{\lambda t}{k} \quad (2)$$

Assume 'n' levels are placed on each side.

The RF Transceiver system obtains the level filled on each side in a given cycle (I1, I2, I3, I4) assuming there are 4 sides at the intersection 'I'.

- Let I₁(a) be the time assigned for the first side of the intersection.
- Let I₂(a) be the time assigned for the second side of the intersection.
- Let I₃(a) be the time assigned for the third side of the intersection.
- Let I₄(a) be the time assigned for the fourth side of the intersection.

$$I_1(a) + I_2(a) + I_3(a) + I_4(a) = T \quad (3)$$

$$a = \frac{T}{I_1 + I_2 + I_3 + I_4} \quad (4)$$

Note: An assumption is made that the minimum distance between 2 signals is approximately equal to 10 times the distance of the maximum level. This assumption allows us to consider the 2 consecutive signals to be independent of each other.

3.3 Figures

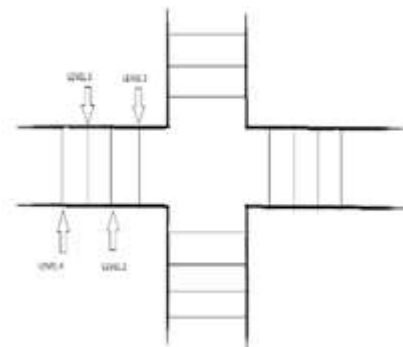


Figure 1: Schematic representation of an intersection.

Note: A transceiver is a blend of a transmitter and a receiver in a single package. The name applies to wireless communication devices like cellular telephones, handheld two-way radios, cordless telephone sets, and mobile two-way radios. Sometimes the term is used in reference to the transmitter or receiver devices in optical fiber systems or cables.

4. Performance

We obtain the waiting times of different sides of the intersection for uniformly distributed traffic times.

The set times are analyzed and tabulated. The RF transmitter receiver based traffic system times are also analyzed similarly and it is observed that these times are lesser and more optimized for the situation compared to the previously fixed traffic times.

For the best performance of the model, this system should be applied to all the signals in a given area.

5. Disadvantages

If a car breaks down obstructing a signal, that level gives a false alarm.

This model doesn't prioritize emergency vehicles and might pose as a hindrance to such vehicles.

Pedestrians might also block the transmitter and might cause slight problems.

6. Future Work

Further improvements can be made to the existing traffic systems by integrating a certain sound detector that only responds to sirens of emergency service vehicles like ambulances and fire engines. This would turn the signal on that particular side of the intersection green enabling lower on road time for emergency vehicles in need.

As this report doesn't consider situations like pedestrians obstructing the signal and also doesn't account for 2 wheelers, the next model can be improved in this regard.

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Author Profile



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